

Specification

Lubricating grease composition for reduction gear and electric power steering apparatus

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Technical Field

The present invention relates to improvement in a lubricating grease composition for a reduction gear (aiming at a lower coefficient of friction), which is optimum for a reduction gear structure of a power steering apparatus or the like of a vehicle and, further, to an electric power steering apparatus in which the lubricating grease composition is used for a reduction gear.

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Background Art

In recent years, resin members are used more frequently in place of various metal members for the sake of reducing the weight of a vehicle or the like. For example, a speed reducing mechanism of an electric power steering apparatus of a vehicle uses a worm wheel gear made of a resin (polyamide) and a worm gear made of steel. As a grease composition used for lubrication between resin members and between a resin member and a metal member, for example, Japanese Patent Laid-open No.

H8-209167 discloses a resin grease composition for lubrication containing a fatty acid including a hydroxyl group or a fatty ester of polyhydric alcohol. The grease composition is excellent with respect to the point that, when it is used for a speed reducing mechanism of an electric power steering apparatus of a vehicle, even after use for long time, fluctuations in the torque are suppressed and the user feels that operation on the steering wheel is normal after long time of driving.

However, when the resin grease composition for lubrication is applied to an electric power steering apparatus of a large car, the load on the lubricating part becomes heavy and use conditions become severe. It causes problems such that the user feels unsmoothness when he/she turns the steering wheel slowly due to increase in static friction, durability deteriorates, and the life becomes shorter.

Japanese Patent Laid-Open No. 2002-371290 filed by the inventors herein discloses a grease composition solving such problems. The composition in the publication is made by an urea compound as a thickener, a synthetic hydrocarbon oil as a base oil, and montan wax as an additive. The outline of the composition is as follows.

The montan wax is a generic name for wax whose material is brown coal and whose base is a montanic acid

obtained by refining and oxidizing the brown coal. Wax manufactured by Clariant International Ltd. is famous. Typified acid wax includes "Licowax U" and "Licowax S" as acid wax, "Licowax E" and "Licowax KPS" as ester wax, 5 "Licowax OP" and "Licowax O" as partial saponifiable ester wax, and the like. Although wax is used as a lubricant for a resin, use of wax as a lubricant for a resin is known. The wax is classified from the viewpoint of actions into an internal lubricant and an external 10 lubricant in accordance with solubility to a polymer (resin). Both of them are used by being added into a resin.

Japanese Patent Publication No. S63-26799

discloses a technique as an example of use of montan wax into a grease. Although the purpose of use is also 15 improvement in lubricating properties, an evaluating method is the Timken test whose object is lubrication between steel and steel, not between resins. The amount of addition of the montan wax is 0.5 to 20%. When the amount of addition is too small, an adding effect is 20 insufficient. When the amount of addition is too large, grease becomes too hard and cannot be used as grease. Any of thickeners can be used but preferable one is an urea-based thickener for the reason that the thickener is low in price and can withstand heat generation caused 25 by lubrication under heavy load.

Further, although all of base oils can be used, particularly, a synthetic hydrocarbon oil is preferable since it matches various resins excellently.

A lubricant grease composition of Japanese Patent
5 Laid-Open No. 2002-371290 produces an effect that it improves abrasion resistance of a reduction gear constructed by a metal worm and a worm wheel made of polyamide synthetic resin. From the viewpoint of improvement in vehicle response and durability, further
10 improvement in a coefficient of friction of a lubricating grease composition is strongly demanded.

The invention has been achieved under such circumstances and an object of the invention is to provide a lubricating grease composition for a reduction gear
15 optimum for an electric power steering apparatus of a vehicle by improving a coefficient of friction and an electric power steering apparatus in which the composition is applied to a reduction gear.

20 Disclosure of the Invention

The present invention relates to a lubricating grease composition for a reduction gear and the object of the invention is achieved by adding, for lubrication of a reduction gear, at least a Ca sulfonate additive
25 to a lubricating grease made by an urea compound as a

thickener and a synthetic hydrocarbon oil as a base oil and is more effectively achieved by also adding montan wax.

The invention also relates to an electric power steering apparatus having a reduction gear structure comprising a steel worm and a worm wheel made of a polyamide synthetic resin, and the object of the invention is achieved by using, for lubrication of the reduction gear structure, a lubricating grease composition made by an urea compound as a thickener and a synthetic hydrocarbon oil as a base oil, to which at least a Ca sulfonate additive is added, and is more effectively achieved by also adding montan wax to the lubricating grease.

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Best Mode for carrying out the Invention

In the present invention, for lubrication of a reduction gear, at least Ca sulfonate additive is added to a lubricating grease made by an urea compound as a thickener and a synthetic hydrocarbon oil as a base oil. By the addition, the coefficient of friction is improved. By also adding montan wax, the coefficient of friction is further improved. By adding Ca sulfonate, an effect of decreasing the sliding performance (coefficient of friction) of a reduction gear constructed by a metal worm

and a worm wheel made of a polyamide synthetic resin at a room temperature or higher can be obtained.

The base oil used for a grease composition of the invention is not particularly limited but all of base
5 oils can be used. Examples are an ester synthetic oil typified by mineral oil, diester, and polyol ester, a synthetic hydrocarbon typified by poly α olefine, and polybutene, an ether synthetic oil typified by alkyl diphenyl ether and polypropylene glycol, silicone oil,
10 fluorine oil, and the like. Among them, the synthetic hydrocarbon oil is particularly preferable. The dynamic viscosity is preferably 6 to 15 mm²/s (100°C).

The thickener used for a grease composition of the invention is not particularly limited and all of
15 thickeners can be used. Examples of the thickener are a soap-based thickener typified by Li soap and composite Li soap, an urea-based thickener typified by diurea, an inorganic thickener typified by organic clay or silica, and an organic thickener typified by PTFE, and the like.
20 A particularly preferable thickener is the urea-based thickener. The urea-based thickener has high resistance to heat generated by lubrication under heavy load and is cheaper than the other thickeners.

The content of the thickener in the grease
25 composition of the invention varies according to the kind

of the thickener. A preferred consistency is 200 to 400 and the content of the thickener is an amount necessary to obtain the preferred consistency. The normal content of the thickener is 3 to 30% by mass.

5 As Ca sulfonate, for example, a calcium metal salt of a sulfonated alkyl-substituted aromatic compound and a material obtained by further overbasing the calcium metal salt with a calcium hydroxide or an oxide and carbon dioxide are preferable. Such sulfonate can have, as a
10 substituent group, an alkyl group having the number of carbons of 1 to 20. As the Ca sulfonate, overbased Ca sulfonate is preferably used since it improves the operation efficiency of an electric power steering gear. Although the base number of the Ca sulfonate is not
15 limited, preferably, it lies from 10 to 500 mgKOH/g, more preferably, 20 to 300 mgKOH/g. Preferably, 0.1 to 10% by weight of the Ca sulfonate is contained in the composition of the invention. More preferably, 0.2 to 3% by weight of the Ca sulfonate is contained.

20 As the montan wax, the above-described acid wax, ester wax, partial saponifiable ester wax, and the like can be used. The content of the montan wax is 0.5 to 20% by mass and, more preferably, 1 to 10% by mass.

 In the electric power steering apparatus of a
25 vehicle, when a motor is driven to generate an assist

torque and a reduction gear operates, self heat generation occurs due to engagement between a steel worm and a worm wheel made of polyamide synthetic resin as components of a reduction gear. When the polyamide synthetic resin is PA6GF30, tooth surface temperature becomes about 60 °C at an outside air temperature of 25 °C. The reduction gear is set so that the interval of gears do not change at an atmospheric temperature as disclosed in, for example, Japanese Patent Laid-Open No. H7-215227. However, in engagement of the gears, the temperature of the polyamide synthetic resin having a high coefficient of linear thermal expansion concentrative rises, so that the interval between the cores in the reduction gear is narrowed and the working torque of the gear decreases. In an uncontrolled range (a small steering angle at the time of straight travel) in the electric power steering apparatus, the low working torque brings about friction at the time of steering the steering wheel. Consequently, when an assist control is continued, the vehicle does not respond to a slight steering angle.

However, in the case of applying the lubricating grease composition of the invention to the reduction gear, the coefficient of friction of the lubricant grease composition can be lowered at a room temperature or higher as compared with that in a conventional one. Consequently,

even if the interval between the cores decreases due to self heat generation of the reduction gear, the working torque does not become low. Thus, predetermined vehicle response which is not influenced by the assist state can
5 be obtained.

The grease composition of the invention can be easily produced by mixing a base oil, a thickener, a montan wax, and at least a Ca sulfonate additive at desired mix proportion.

10 The kind of the resin to be lubricated by the grease composition of the invention is not particularly limited to the polyamide resin (nylon). For example, a polyamide-imide resin, a polyacetal resin, a polybutylene terephthalate resin, a polyether ether
15 ketone resin, a polyphenylene sulfide resin, and the like are also effective. A synthetic resin obtained by reinforcing any of the above resins by an additive such as glass fibers, carbon fibers, or the like is also effective.

20 Example

The coefficient of friction in the case where an overbased Ca sulfonate is added to a composition as a base obtained by mixing diurea A as a thickener, PAO(8)
25 as a base oil, and montan wax as an additive was evaluated

by Bowden test.

Conditions:

Material ... a plate of S45C and a rod of MC nylon (made by Nippon Polypenco Limited)

5 Sliding speed ... 1 mm/sec

Surface pressure ... 0.5 Mpa

(1) The effect of adding the Ca sulfonate at different temperatures is shown in the following table 1. "○" is filled in items in which the coefficient of friction was lower than that of a conventional one (in the case where the Ca sulfonate is not added) and "△" is filled in items in which the coefficient of friction is unchanged. In the example, the consistency is fixed at "285" at each of the temperatures and the addition amount of the Ca sulfonate is fixed to 0.5%.

Table 1

| Temperatu re | -40°C | -10°C | 23°C | 60°C | 90°C | 120°C |
|-----------------|-------|-------|------|------|------|-------|
| | △ | △ | △ | ○ | ○ | ○ |

Consistency: fixed at 285

Addition amount: fixed at 0.5%

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(2) The effect of adding the Ca sulfonate is shown in the following table 2. "○" is filled in items in which

the coefficient of friction was lower than that of a conventional one (in the case where the Ca sulfonate is not added) and "△" is filled in item in which the coefficient of friction is unchanged. In the example,

5 the consistency is fixed at "285".

Table 2

| Addition amount | 0.5% | 1% | 2% | 3% |
|-----------------------------|--------|--------|--------|--------|
| Room temperature 60°C | △ ○ | ○ ○ | ○ ○ | ○ ○ |

Consistency: fixed at 285

10 (3) The effect of consistency when the addition amount of the Ca sulfonate is fixed is shown in the following table 3. "○" is filled in items in which the coefficient of friction was lower than that of a conventional one (in the case where the Ca sulfonate is

15 not added) and "△" is filled in items in which the coefficient of friction is unchanged. The addition amount of Ca sulfonate is fixed at 0.5%.

Table 3

| Consistency | 305 | 295 | 285 | 275 |
|-------------|-----|-----|-----|-----|
|-------------|-----|-----|-----|-----|

| | | | | |
|-------------|---|---|---|---|
| Room | ○ | △ | △ | ○ |
| temperature | ○ | ○ | ○ | ○ |
| 60°C | | | | |

Addition amount: fixed at 0.5%

Industrial Applicability

In the invention, a lubricating grease composition
5 is obtained by adding at least a Ca sulfonate additive
to a lubricating grease made by an urea compound as a
thickener and a synthetic hydrocarbon oil as a base oil.
The result of the Bowden test in the case where the Ca
sulfonate additive is added and that in the case where
10 the Ca sulfonate additive is not added are obvious from
the tables 1 to 3. The coefficient of friction at room
temperature or higher in the case where the Ca sulfonate
additive is added is largely improved.

Since the coefficient of friction can be decreased
15 at room temperature or higher by the lubricating grease
composition of the invention, in the case of applying
the lubricating grease composition of the invention to
a reduction gear structure of an electric power steering
apparatus of a vehicle, even if the interval between cores
20 is narrowed due to self heat generation of the reduction
gear, the working torque does not become low. Thus, there
is an advantage that predetermined vehicle response which

is not influenced by the assist state can be obtained.